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for

**SYSTEM AND METHOD FOR INCREASING THE SPEED OF
SERIALLY INPUTTING DATA INTO A JTAG-COMPLIANT DEVICE**

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**System and Method for Increasing the Speed of
Serially Inputting Data into a JTAG-Compliant Device**

BACKGROUND OF THE INVENTION

1. Technical Field

5 The present invention relates in general to a system and method for increasing the speed of serially inputting data into a JTAG-compliant device. In particular, the present invention relates to a system and a method for inputting data into the device through the control (TMS)
10 line as well as through the data input (TDI) line.

2. Description of the Related Art

 Joint Test Action Group (JTAG), or IEEE Standard 1149.1, is a standard specifying how to identify, control, test, and monitor JTAG-compliant devices (such as
15 microprocessors, memory, etc.) on a printed circuit board. Each JTAG-compliant device, in addition to the device's own communication lines, has five additional lines for supporting the JTAG protocol. The lines include a clock (TCK) line, a control (TMS) line for controlling the
20 operation of the device's JTAG-related components, and a common reset (TRST) for resetting the JTAG-portion of the device. In addition, the lines include a data input (TDI) line for serially inputting data into the device and an output data (TDO) line for daisy chaining one device's data
25 output to another's data input.

 Internally, a JTAG-compliant device contains a test access protocol (TAP) controller, a state machine whose state is controlled by the signal received on the control

(TMS) line. By traversing the different states of the test access protocol (TAP) controller, data can be loaded into and read from internal data and instruction registers, typically for the purpose of determining the proper operation of the device. For example, an instruction can be loaded, followed by data which is processed according to the loaded instruction. For more details on the JTAG-IEEE 1149.1 specification, please refer to IEEE's website: <http://www.ieee.org>.

According to the JTAG specification, the inputting of data into the test access protocol (TAP) controller and the outputting of data out of the test access protocol (TAP) controller is limited to data on the input (TDI) and output (TDO) lines, respectively. Data on these lines flows at the rate of one bit every clock cycle. In cases where many JTAG operations are required and/or many JTAG-compliant devices exist on a printed circuit board, this limitation can significantly increase the time required to run tests or other JTAG-related procedures. Data compression techniques can be used in order to increase the data flow, but such approaches tend to be complex and difficult to implement.

What is needed, therefore, is a system and method that increases the rate at which data can be inputted into a JTAG-compliant device. The system and method should provide the capability to increase the data rate without significantly increasing complexity. At the same time, the operation of the device should remain within the IEEE JTAG protocol in order not to preclude testing of the device using other JTAG-compliant methods.

SUMMARY

5 It has been discovered that the aforementioned challenges are addressed by a method and system that enable the test access protocol (TAP) controller of a JTAG-compliant device to receive and store bits of data through the control (TMS) line in addition to the test access protocol (TAP) controller's ability to receive and store bits of data through the input (TDI) line.

10 A burst-write instruction is first made the active instruction of the test access protocol (TAP) controller of a JTAG-compliant device. The burst-write instruction is received through the input (TDI) line of the test access protocol (TAP) controller and is loaded into the instruction register of the test access protocol (TAP)
15 controller. The burst-write instruction extends the capability of the test access protocol (TAP) controller such that the test access protocol (TAP) controller can receive data into a data register while the test access protocol (TAP) controller is in certain states.

20 In certain states, the test access protocol (TAP) controller receives and stores a bit of data through the input (TDI) line on a subsequent clock cycle in response to the burst-write instruction being the active instruction in the test access protocol (TAP) controller. At other
25 states, the test access protocol (TAP) controller receives and stores a bit of data through the input (TDI) line, and in addition, the test access protocol (TAP) controller receives and stores a bit of data through the control (TMS) line on a subsequent clock cycle in response to the burst-

write instruction being the active instruction in the test access protocol (TAP) controller. The test access protocol (TAP) controller stores the received bits by shifting the received bits into the least significant bit of a data register designated to receive data when the burst-write instruction is the active instruction. The received bits are shifted into the data register on the rising (IEEE compatible) or falling edge of the clock signal.

By inputting data through both the input (TDI) and control (TMS) lines, an increase in the data input speed of up to 50%, on average, can be achieved. When a low signal (0) is to be received on the control line, data can be received through both the control and the input lines increasing the data input rate by 100%. When a high signal (1) is to be received through the control line data is received only through the input line. Since, in general, there is an equal likelihood of receiving a low signal or a high signal, on average, there is a 50% increase in the rate of inputting data to the TAP controller.

The foregoing is a summary and thus contains, by necessity, simplifications, generalizations, and omissions of detail; consequently, those skilled in the art will appreciate that the summary is illustrative only and is not intended to be in any way limiting. Other aspects, inventive features, and advantages of the present invention, as defined solely by the claims, will become apparent in the non-limiting detailed description set forth below.

BRIEF DESCRIPTION OF THE DRAWINGS

5 The present invention may be better understood, and its numerous objects, features, and advantages made apparent to those skilled in the art by referencing the accompanying drawings. The use of the same reference symbols in different drawings indicates similar or identical items.

10 **Figure 1** is a block diagram illustrating a JTAG-compliant device configured to accept data through the control (TMS) and input (TDI) lines;

Figure 2 is a logic state diagram illustrating the operation of the test access protocol (TAP) controller of a JTAG-compliant device;

15 **Figure 3** is a flowchart illustrating a method for switching between the different states of a test access protocol (TAP) controller;

Figure 4 is a flowchart illustrating a method for loading data into the data register of a test access protocol (TAP) controller;

20 **Figure 5** is a flowchart illustrating a method for loading data into the instruction register of a test access protocol (TAP) controller;

25 **Figure 6** is a block diagram illustrating a serial chain of test access protocol (TAP) controllers using one control (TMS) signal;

Figure 7 is a block diagram illustrating two parallel serial chains of test access protocol (TAP) controllers;

Figure 8 is a block diagram illustrating a chain of test access protocol (TAP) controllers having multiple independent paths with common control (TMS) and clock (TCK) signals; and

Figure 9 illustrates an information handling system that is a simplified example of a computer system capable of performing the operations described herein.

DETAILED DESCRIPTION

The following is intended to provide a detailed description of an example of the invention and should not be taken to be limiting of the invention itself. Rather,
5 any number of variations may fall within the scope of the invention defined in the claims following the description.

Figure 1 is a block diagram illustrating a JTAG-compliant device configured to accept data through the device's input (TDI) line as well as through the device's control (TMS) line. In one embodiment, the JTAG-compliant device, such as chip **110**, includes lines **165**, **170**, and **175**, which are configured to input and output data to and from chip logic **115**. Chip logic **115** is configured to perform the functions of chip **110**, other than the chip's JTAG-related functions. For example, chip **110** may be a
10 microprocessor configured to receive special instructions and process data accordingly, a memory configured to receive and store data, or a chip designed to perform any number of functions.
15

Chip **110** includes JTAG-related components such as Test Access Protocol (TAP) controller **120** and a number of registers such as registers **125**, **130**, and **135**. Registers **125**, **130**, and **135** are configured to store instructions and data used during JTAG-related functions,
20 such as testing of the device. Test access protocol (TAP) controller **120** is a state machine and is configured to control the operation of the JTAG portion of chip **110** and to provide the interface between JTAG components and other components on chip **110**.
25

Lines **140-160** are configured to input and output data to and from test access protocol (TAP) controller **120**. Line **140** (TCK) provides the synchronizing clock signal, line **145** (TMS) provides the control signal that controls the state of test access protocol (TAP) controller **120**, line **150** common reset (TRST) provides a reset signal for resetting test access protocol (TAP) controller **120** to the controller's initial state, line **155** input (TDI) provides bit-by-bit serial data input to test access protocol (TAP) controller **120**, and line **160** output (TDO) provides data output for daisy-chaining chip **110** to other JTAG-compliant devices. Test access protocol (TAP) controller **120** is configured to receive data through control (TMS) line **145** in addition to being configured to receive data through input (TDI) line **155** in order to increase the speed of data input to the test access protocol (TAP) controller.

Figure 2 is a logic state diagram illustrating the operation of the test access protocol (TAP) controller of a JTAG-compliant device. During initialization, the test access protocol (TAP) controller is placed at the Test-Logic-Reset state. The test access protocol (TAP) controller is configured to return to the Test-Logic-Reset state upon the test access protocol (TAP) controller's receiving of a reset signal (through the common reset (TRST) line). The changing of the state of the test access protocol (TAP) controller is controlled by the signal received through the control (TMS) line. The "0" and "1" arrows show how the state of the test access protocol (TAP) controller changes depending on whether the test access protocol (TAP) controller receives a low or high signal through the control line. The flowchart of **Figure 3**

provides more details on the behavior of the TAP controller at the states: test-logic-reset **200**, run-test/idle state **205**, select-data-register-scan state **210**, select-instruction-register-scan **250**, update-data-register state **240**, and update-instruction-register **280**.

The test access protocol (TAP) controller's state diagram consists of two main branches: the data register (DR) branch where data are loaded into data registers and the instruction register (IR) branch where data are loaded into instruction registers.

More details on the operation of the test access protocol (TAP) controller and the behavior of the test access protocol (TAP) controller at the data register branch states (capture-data-register state **215**, shift-data-register state **220**, exit1-data-register state **225**, pause-data-register **230**, and exit2-data-register state **235**) are provided in the flowchart of **Figures 4**. In one embodiment, the test access protocol (TAP) controller is configured to receive data into a data register through the control (TMS) and input (TDI) lines when the controller is in Shift data register state **220** and Pause data register state **230** in response to a burst-write instruction being the active instruction in the test access protocol (TAP) controller. In addition, in one embodiment, the test access protocol (TAP) controller is configured to receive data into the data register through the input (TDI) line when the controller is in the Exit1 data register state **225** and Exit2 data register state **235** in response to the burst-write instruction being the active instruction in the test access protocol (TAP) controller.

More details on the operation of the test access protocol (TAP) controller and the behavior of the test access protocol (TAP) controller at the instruction register branch states (capture-instruction-register state **255**, shift-instruction-register state **260**, exit1-instruction-register state **265**, pause-instruction-register **270**, and exit2-instruction-register state **275**) are provided in the flowchart of **Figures 5**.

Figure 3 is a flowchart illustrating a method for switching between the different states and thus controlling the operation of a test access protocol (TAP) controller. Processing begins at **300** whereupon, at step **310**, the test access protocol (TAP) controller is initialized (powered-up) and reset to the test-logic-reset state. In one embodiment, the test access protocol (TAP) controller is placed in the test-logic-reset state during initialization of the system. The test access protocol (TAP) controller may also return to the test-logic-reset state when a reset signal is received through the test reset (TRST) line of the test access protocol (TAP) controller. A determination is then made as to whether a high or low signal is received on the control (TMS) line of the test access protocol (TAP) controller during the next clock cycle at decision **315**.

If a high signal is received through the control (TMS) line, decision **315** branches to the "1" branch whereupon processing returns to step **310**, and the test access protocol (TAP) controller remains in the test-logic-reset state. If a low signal is received through the control (TMS) line, decision **315** branches to the "0" branch whereupon, at step **320**, the test access protocol (TAP)

controller advances to the run-test/idle state. The run-test/idle state is a state between scan operations. In this state, the contents of all test data registers retain their previous value. When certain instructions are present, activity in selected test logic may occur. A determination is then made as to whether a high or low signal is received on the control (TMS) line of the test access protocol (TAP) controller during the next clock cycle at decision **325**. If a low signal is received through the control (TMS) line, decision **325** branches to the "0" branch whereupon processing returns to step **320** where the test access protocol (TAP) controller remains at the run-test/idle state.

On the other hand, if a high signal is received through the control (TMS) line, decision **325** branches to the "1" branch whereupon, at step **330**, the test access protocol (TAP) controller advances to the select data register scan (select-data-register scan) state. The select data register scan state is the first state in the data register branch of the test access protocol (TAP) controller. This is typically a temporary state where all registers selected by the active instruction retain their previous values. A determination is then made as to whether a high or low signal is received on the control (TMS) line of the test access protocol (TAP) controller during the next clock cycle at decision **335**. If a low signal is received through the control (TMS) line, decision **335** branches to the "0" branch whereupon, at predefined process **340**, data is loaded into the selected data register of the test access protocol (TAP) controller. More details on the processing that takes place during

predefined process **340** are provided in the flowchart and corresponding text of **Figure 4**.

Processing continues at step **345** where the test access protocol (TAP) controller advances to the update data register (update-data-register) state. At this state, data from the shift data registers are output in parallel to other test data registers. A determination is then made as to whether a high or low signal is received on the control (TMS) line of the test access protocol (TAP) controller during the next clock cycle at decision **350**. If a high signal is received through the control (TMS) line, decision **350** branches to the "1" branch whereupon processing returns to step **330** and the test access protocol (TAP) controller returns to the select data register-scan state. If a low signal is received through the control (TMS) line, decision **350** branches to the "0" branch whereupon processing returns to step **320** and the test access protocol (TAP) controller returns to the run-test/idle state.

Returning to decision **335**, if a high signal is received through the control (TMS) line, decision **335** branches to the "1" branch whereupon processing continues at step **360** where the test access protocol (TAP) controller advances to the select instruction register scan (select-instruction-register-scan) state. The select instruction register scan state is the first state in the instruction register branch of the test access protocol (TAP) controller. This is typically a temporary state where all registers selected by the active instruction retain their previous values. A determination is then made as to

whether a high or low signal is received on the control (TMS) line of the test access protocol (TAP) controller during the next clock cycle at decision **365**. If a high signal is received through the control (TMS) line, decision **365** branches to the "1" branch whereupon processing returns to step **310** where the test access protocol (TAP) controller returns to the test-logic-reset state.

On the other hand, if a low signal is received through the control (TMS) line, decision **365** branches to the "0" branch whereupon, at predefined process **370**, instructions are loaded into the instruction register of the test access protocol (TAP) controller. More details on the processing that takes place at predefined process **370** are provided in the flowchart and corresponding text of **Figure 5**.

After predefined process **370**, processing continues at step **375** where the test access protocol (TAP) controller advances to the update instruction register (update-instruction-register) state. At this state, data from the shift instruction registers is output in parallel to the test instruction register and become the new active instruction. A determination is then made as to whether a high or low signal is received on the control (TMS) line of the test access protocol (TAP) controller during the next clock cycle at decision **380**. If a high signal is received through the control (TMS) line, decision **380** branches to the "1" branch whereupon processing returns to step **330** where the test access protocol (TAP) controller returns to the select data register scan state. If a low signal is received through the control (TMS) line, decision **380**

branches to the "0" branch whereupon processing returns to step **320** where the test access protocol (TAP) controller returns to the run-test/idle state.

Figure 4 is a flowchart illustrating a method for loading data into the data register of a test access protocol (TAP) controller. Processing begins at **400** whereupon, at step **410**, the test access protocol (TAP) controller advances to the capture data register state. In this state, data may be loaded in parallel into data registers selected by the active instruction. A determination is then made as to whether a high or low signal is received on the control (TMS) line of the test access protocol (TAP) controller during the next clock cycle at decision **415**. If a high signal is received through the control (TMS) line, decision **415** branches to the "1" branch whereupon processing returns to step **410** where the test access protocol (TAP) controller remains at the capture data register state.

If a low signal is received through the control (TMS) line, decision **415** branches to the "0" branch whereupon the test access protocol (TAP) controller advances to the shift data register state at step **420**. If a special opcode value has been placed in the instruction register, the test access protocol (TAP) controller is placed in burst-write mode. Data inputted through the input (TDI) line and data inputted through the control (TMS) line are shifted into a special "shadow" data register. In one embodiment, the shadow data register has alternate shift-in semantics in order to accept additional data from the control (TMS) line as will be described below. The shadow data register may

have one additional bit compared to the other registers of the test access protocol (TAP) controller. For example, if the other registers are 32 bits long, the shadow data register may be 33 bits long. If the other registers are **128** bits long, the shadow data register may be **129** bits long, etc.

At the next clock cycle, at step **425**, a bit from the control (TMS) signal is shifted into the least significant bit (LSB) of the shadow data register followed by a bit from the input (TDI) control (TMS) signal. A determination is then made as to whether a high or low signal is received on the control (TMS) line of the test access protocol (TAP) controller during the next clock cycle at decision **430**. If a low signal is received through the control (TMS) line, decision **430** branches to the "0" branch whereupon processing returns to step **420** where the test access protocol (TAP) controller remains in the shift data register state and two more bits are shifted into the shadow data register as described above.

On the other hand, if a high signal is received through the control (TMS) line, decision **430** branches to the "1" branch whereupon, at step **435**, the test access protocol (TAP) controller advances to the exit1 data register state. At step **440**, a bit from the input (TDI) signal is shifted into the shadow data register. At this state, the control (TMS) bit is used to determine whether to exit or continue inputting data. The control (TMS) signal is not used for data input. A determination is made as to whether a high or low signal is received on the control (TMS) line of the test access protocol (TAP)

controller during the next clock cycle at decision **445**. If a high signal is received through the control (TMS) line, decision **445** branches to the "1" branch whereupon processing returns to the calling routine at **499**.

5 On the other hand, if a low signal is received through the control (TMS) line, decision **445** branches to the "0" branch whereupon, at step **450**, the test access protocol (TAP) controller advances to the pause data register state, a stage similar to the shift data register state. At
10 step **455**, a bit from the control (TMS) signal is shifted into the shadow data register followed by a bit from the input (TDI) signal. A determination is then made as to whether a high or low signal is received on the control (TMS) line of the test access protocol (TAP) controller
15 during the next clock cycle at decision **460**. If a low signal is received through the control (TMS) line, decision **460** branches to the "0" branch whereupon processing returns to step **450** where the test access protocol (TAP) controller remains in the pause data
20 register state where two more bits can be shifted into the shadow data register from the control (TMS) and input (TDI) lines.

 On the other hand, if a high signal is received through the control (TMS) line, decision **460** branches to
25 the "1" branch whereupon, at step **465**, the test access protocol (TAP) controller advances to the exit2 data register state, a state similar to the exit1 data register state. At step **470**, a bit from the input (TDI) signal is shifted into the shadow data register. A determination is
30 then made as to whether a high or low signal is received on

the control (TMS) line of the test access protocol (TAP) controller during the next clock cycle at decision **475**. If a high signal is received through the control (TMS) line, decision **475** branches to the "1" branch whereupon processing returns to the calling routine at **499**.

If a low signal is received through the control (TMS) line, decision **475** branches to the "0" branch whereupon, at step **480**, the test access protocol (TAP) controller returns to the shift data register state where two additional bits can be shifted into the shadow data register.

In an embodiment where a 33-bit-long shadow data register is being used, when 32 or 33 bits have been shifted into the data register, the 32 most significant (older) bits are output to another register/logic. If 33 bits have been shifted into the data register, one bit remains in the data register. Because the data input states cannot be exited immediately (as is the case under normal operation), it may be necessary to "pad" the data stream with some "junk" data in order to reach the exit1 data register state or exit2 data register state and exit the "data" branch of the test access protocol (TAP) controller.

Figure 5 is a flowchart illustrating a method for loading data into the instruction register of a test access protocol (TAP) controller. Processing begins at **500** whereupon, at step **510**, the test access protocol (TAP) controller advances to the capture instruction register state. In this state, data may be loaded in parallel into the instruction register. A determination is then made as

to whether a high or low signal is received on the control (TMS) line of the test access protocol (TAP) controller during the next clock cycle at decision **515**. If a high signal is received through the control (TMS) line, decision **515** branches to the "1" branch whereupon processing returns to step **510** where the test access protocol (TAP) controller remains at the capture instruction register state.

If a low signal is received through the control (TMS) line, decision **515** branches to the "0" branch whereupon the test access protocol (TAP) controller advances to the shift instruction register state at step **520**. During the next clock cycle, at step **525**, a bit from the input (TDI) signal is shifted into the LSB of the instruction register. A determination is then made as to whether a high or low signal is received on the control (TMS) line of the test access protocol (TAP) controller during the next clock cycle at decision **530**. If a low signal is received through the control (TMS) line, decision **530** branches to the "0" branch whereupon processing returns to step **520** where the test access protocol (TAP) controller remains in the shift instruction register state where one more bit can be shifted into the instruction register as described above.

On the other hand, if a high signal is received through the control (TMS) line, decision **530** branches to the "1" branch whereupon, at step **535**, the test access protocol (TAP) controller advances to the exit1 instruction register state. A determination is then made as to whether a high or low signal is received on the control (TMS) line of the test access protocol (TAP) controller during the

next clock cycle at decision **545**. If a high signal is received through the control (TMS) line, decision **545** branches to the "1" branch whereupon processing returns to the calling routine at **599**.

5 On the other hand, if a low signal is received through the control (TMS) line, decision **545** branches to the "0" branch whereupon, at step **550**, the test access protocol (TAP) controller advances to the pause instruction register state. A determination is then made as to whether a high
10 or low signal is received on the control (TMS) line of the test access protocol (TAP) controller during the next clock cycle at decision **560**. If a low signal is received through the control (TMS) line, decision **560** branches to the "0" branch whereupon processing returns to step **550** where the
15 test access protocol (TAP) controller remains in the pause instruction register state.

 On the other hand, if a high signal is received through the control (TMS) line, decision **560** branches to the "1" branch whereupon, at step **565**, the test access
20 protocol (TAP) controller advances to the exit2 instruction register state, a state similar to the exit1 instruction register state. A determination is then made as to whether a high or low signal is received on the control (TMS) line of the test access protocol (TAP) controller during the
25 next clock cycle at decision **575**. If a low signal is received through the control (TMS) line, decision **575** branches to the "0" branch whereupon, at step **520**, the test access protocol (TAP) controller returns to the shift instruction register state where one additional bit can be
30 shifted into the instruction register.

If a high signal is received through the control (TMS) line, decision **575** branches to the "1" branch whereupon processing returns to the calling routine at **599**.

Figure 6 is a block diagram illustrating a serial chain of test access protocol (TAP) controllers using one control (TMS) signal. Test access protocol (TAP) controllers **610**, **615**, **620**, and **625** are connected in series to each other and are sharing clock signal (TCK) **630** and test mode select control (TMS) signal **635**. The input signal is provided to the input (TDI) line **640** of the first test access protocol (TAP) controller (**610**), and from output (TDO) line **645** of the test access protocol (TAP) controller the signal is provided to the next test access protocol (TAP) controller in the chain, etc.

In this configuration, the control (TMS) and clock (TCK) signals are common between the test access protocol (TAP) controllers, and as such, the state of each test access protocol (TAP) controller is in lockstep. Burst-write mode can be used in this configuration since a "bypass" opcode in the instruction register keeps data register actions from having any effect on chips that have not been "selected."

Figure 7 is a block diagram illustrating two parallel serial chains of test access protocol (TAP) controllers. Test access protocol (TAP) controller **715** is connected in series to test access protocol (TAP) controller **725**, and TAP controller **710** is connected in parallel to test access protocol (TAP) controller **720**. (Test access protocol (TAP) controller **715** and TAP controller **725**) The first pair is

connected in parallel to the second pair (Test access protocol (TAP) controller **710** and TAP controller **720**.) The first and second controller pairs share clock **730** (TCK) and data input **735** (TDI) signals, but the first and second pairs each has its own control (TMS) signal (TMS1 **740** used by the first pair and TMS2 **745** used by the second pair.).

In this configuration, the TMS and clock (TCK) signals are common between all of the test access protocol (TAP) controllers. Since, at any time, only one serial chain is actively scanning, this configuration is equivalent to the serial configuration shown in **Figure 6**. Burst-write mode can be used in this configuration since a "bypass" opcode in the instruction register keeps data register actions from having any effect on chips in the serial chain that have not been "selected".

Figure 8 is a block diagram illustrating a chain of test access protocol (TAP) controllers having multiple independent data paths with common control (TMS) and clock (TCK) signals. Test access protocol (TAP) controllers **810**, **815**, **820**, and **825** are connected in parallel to each other. The test access protocol (TAP) controllers have common clock (TCK) signal **830** and common control (TMS) signal **835**, but each of the test access protocol (TAP) controllers has a separate data input signal, TDI1 **840**, TDI2 **845**, TDI3 **850**, & TDI4 **855**, respectively. Each also has a separate data output signal TDO1 **860**, TDO2 **865**, TDO3 **870**, and TDO4 **875**, respectively. The output lines can be used to provide the input signals into the TAP controllers to additional TAP controllers that

may be connected to the existing configuration of TAP controllers.

In this configuration, the test access protocol (TAP) controllers share common control (TMS) line **835**. Thus, burst-mode would be possible when all the test access protocol (TAP) controllers are to receive the same data. The same signal is then sent on all of the input lines (TDI1 **840**, TDI2 **845**, TDI3 **850**, & TDI4 **855**). In this case, the system behaves similarly to the system shown in **Figure 6**.

Figure 9 illustrates information handling system **901** which is a simplified example of a computer system capable of performing the computing operations described herein. Computer system **901** includes processor **900** which is coupled to host bus **902**. A level two (L2) cache memory **904** is also coupled to host bus **902**. Host-to-PCI bridge **906** is coupled to main memory **908**, includes cache memory and main memory control functions, and provides bus control to handle transfers among PCI bus **910**, processor **900**, L2 cache **904**, main memory **908**, and host bus **902**. Main memory **908** is coupled to Host-to-PCI bridge **906** as well as host bus **902**. Devices used solely by host processor(s) **900**, such as LAN card **930**, are coupled to PCI bus **910**. Service Processor Interface and ISA Access Pass-through **912** provides an interface between PCI bus **910** and PCI bus **914**. In this manner, PCI bus **914** is insulated from PCI bus **910**. Devices, such as flash memory **918**, are coupled to PCI bus **914**. In one implementation, flash memory **918** includes BIOS code that incorporates the necessary processor

executable code for a variety of low-level system functions and system boot functions.

5 PCI bus **914** provides an interface for a variety of devices that are shared by host processor(s) **900** and Service Processor **916** including, for example, flash memory **918**. PCI-to-ISA bridge **935** provides bus control to handle transfers between PCI bus **914** and ISA bus **940**, universal serial bus (USB) functionality **945**, power management functionality **955**, and can include other
10 functional elements not shown, such as a real-time clock (RTC), DMA control, interrupt support, and system management bus support. Nonvolatile RAM **920** is attached to ISA Bus **940**. Service Processor **916** includes JTAG and I2C busses **922** for communication with processor(s) **900** during
15 initialization steps. JTAG/I2C busses **922** are also coupled to L2 cache **904**, Host-to-PCI bridge **906**, and main memory **908** providing a communications path between the processor, the Service Processor, the L2 cache, the Host-to-PCI bridge, and the main memory. Service Processor **916**
20 also has access to system power resources for powering down information handling device **901**.

Peripheral devices and input/output (I/O) devices can be attached to various interfaces (e.g., parallel interface **962**, serial interface **964**, keyboard
25 interface **968**, and mouse interface **970** coupled to ISA bus **940**. Alternatively, many I/O devices can be accommodated by a super I/O controller (not shown) attached to ISA bus **940**.

In order to attach computer system **901** to another computer system to copy files over a network, LAN card **930** is coupled to PCI bus **910**. Similarly, to connect computer system **901** to an ISP to connect to the Internet using a telephone line connection, modem **975** is connected to serial port **964** and PCI-to-ISA Bridge **935**.

While the computer system described in **Figure 9** is capable of executing the processes described herein, this computer system is simply one example of a computer system. Those skilled in the art will appreciate that many other computer system designs are capable of performing the processes described herein.

One of the preferred implementations of the invention is an application, namely, a set of instructions (program code) in a code module which may, for example, be resident in the random access memory of the computer. Until required by the computer, the set of instructions may be stored in another computer memory, for example, on a hard disk drive, or in removable storage such as an optical disk (for eventual use in a CD ROM) or floppy disk (for eventual use in a floppy disk drive), or downloaded via the Internet or other computer network. Thus, the present invention may be implemented as a computer program product for use in a computer. In addition, although the various methods described are conveniently implemented in a general purpose computer selectively activated or reconfigured by software, one of ordinary skill in the art would also recognize that such methods may be carried out in hardware, in firmware, or in more specialized apparatus constructed to perform the required method steps.

While particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that, based upon the teachings herein, changes and modifications may be made without departing from this invention and its broader aspects and, therefore, the appended claims are to encompass within their scope all such changes and modifications as are within the true spirit and scope of this invention. Furthermore, it is to be understood that the invention is solely defined by the appended claims. It will be understood by those with skill in the art that if a specific number of an introduced claim element is intended, such intent will be explicitly recited in the claim, and in the absence of such recitation no such limitation is present. For a non-limiting example, as an aid to understanding, the following appended claims contain usage of the introductory phrases "at least one" and "one or more" to introduce claim elements. However, the use of such phrases should not be construed to imply that the introduction of a claim element by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim element to inventions containing only one such element, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an"; the same holds true for the use in the claims of definite articles.